NATURE AND VARIABILITY OF CORONAL STREAMERS AND THEIR RELATIONSHIP TO THE SLOW SPEED WIND

NASA Grant NAG5-12781

Annual Report No. 2

For the period 1 February 2004 to 31 January 2005

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May 2005

Prepared for
National Aeronautics and Space Administration
Greenbelt, MD 20771

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The Smithsonian Astrophysical Observatory
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Harvard-Smithsonian Center for Astrophysics

1. Introduction

NASA Grant NAG5-12781 is a study on the "Nature and Variability of Coronal Streamers and their Relationship to the Slow Speed Wind." The two main goals of this study are to identify: *1)* Where in the streamer structure does the solar wind originate, and *2)* What coronal conditions are responsible for the variability of the slow speed wind.
To answer the first question, we examined the mostly closed magnetic field regions in streamer cores to search for evidence of outflow. Preliminary results from the OVI Doppler dimming ratios indicates that most of the flow originates from the edges of coronal streamers but this idea should be confirmed by a comparison of the coronal plasma properties with in situ solar wind data. To answer the second question, the work performed thus far suggests that solar minimum streamers have larger perpendicular velocity distributions than do solar maximum streamers. If it can be shown that solar minimum streamers also produce higher solar wind speeds then this would suggest that streamers and coronal holes have similar solar wind acceleration mechanisms.

The key to both questions lie in the analysis of the in situ solar wind data sets. This work was not able to be completed during the period of performance and therefore the grant was formally extended for an additional year at no cost to NASA. We hope to have final results and a publication by the end of the calendar year 2004.

The SAO personnel involved in the research are Leonard Strachan (PI), Mari Paz Miralles, Alexander Panasyuk, and a Southern University student Michael Baham.

2. Activities and highlights of scientific results from the second year.

2.1 Streamer variability over the solar cycle.

One approach to studying the variability of streamers of is to look at the same streamer over many coronal rotations and the other is to look at different streamers. The first approach is easier and offers a more systematic way of examining change. In fact during solar minimum the streamer belt is essentially a continuous arcade around the Sun and so we can treat this as one super-structure in the corona. Panasyuk has produced a new set of coronal synoptic maps which show how the OVI and Ly-alpha intensities and velocity distributions change during the transition from solar minimum to maximum. The data is being supplemented with higher quality data from dedicated streamer observations to confirm the general trends in the data set.

The dedicated streamer observations were selected so that they were free from contamination of active regions or coronal mass ejection emission. All of the solar minimum streamers were on the equatorial streamer belt. At solar maximum the streamer belt is warped and tilted and is no longer near the solar equator. In this case, streamers were selected that lie above the dominant current sheet that separated positive and negative magnetic polarities (based on Wilcox Solar Observatory magnetogram data).

This solar minimum streamer results were presented at the AAS/SPD meeting (Strachan et al., 2004a) and the comparison with solar maximum streamers was presented at the SOHO 15 Workshop (Strachan et al., 2004b). Figure 1 is plot of O^{5+} kinetic temperatures (velocity distributions) which shows that solar minimum equatorial streamers have about twice the perpendicular heating than do streamers at solar maximum. We hope to improve the statistics of this plot by including many more streamers from the synoptic data set.

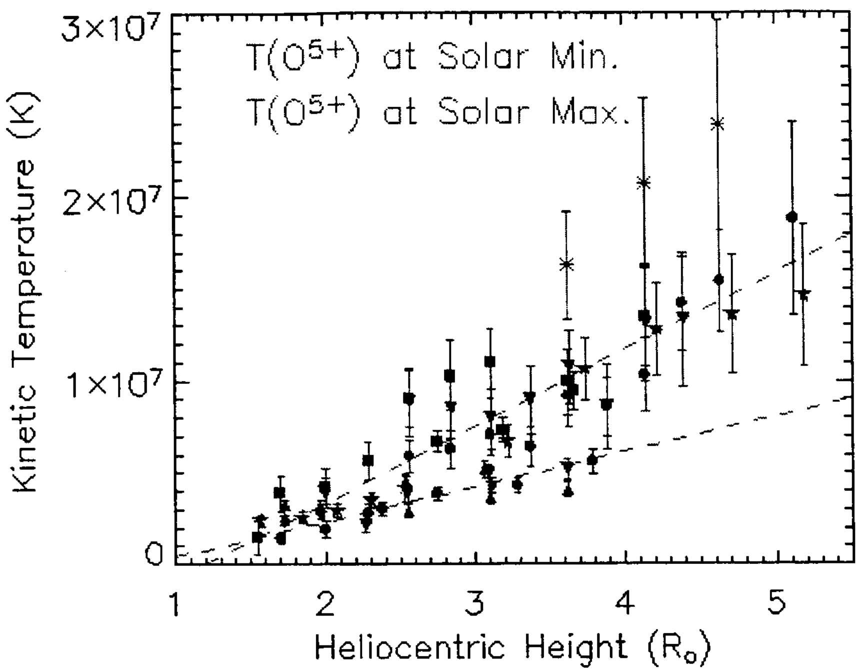

Figure 1. Plot of O^{5+} kinetic temperatures as a function of heliocentric height along the axis for solar minimum and solar maximum streamers showing that the slope for solar minimum streamers is twice that for solar maximum streamers (Strachan et al., 2004b).

The proton velocity distributions were also studied and they show that contrary to the ever increasing O^{5+} kinetic temperatures, the protons reach a maximum temperature at about 2.5 MK at 2.5 solar radii (Strachan et al., 2004b). A possible interpretation of this is that 2.5 solar radii is the top of the closed magnetic field regions within streamers (at solar maximum). The decrease in proton kinetic temperatures could indicate a transition between two regions where below 2.5 R_O more energy goes into heating in closed regions and above 2.5 R_O where more energy goes into accelerating the solar wind plasma.

The next step is to compare the solar minimum and maximum outflow velocities – in the corona from the OVI 1032/2037 line ratios and at ~ 1 AU using in situ velocity measurements from ACE, SOHO, and Ulysses. The behavior of the outflow velocities will then be compared to the behavior of the kinetic temperatures in Fig. 1 to show if there is indeed a strong correlation between kinetic temperature and outflow speed.

2.2 Solar wind source regions within streamers.
Detection of solar wind flow within streamers has been more elusive. The Doppler dimming outflow velocity diagnostic is not as sensitive to the low outflow speeds expected but there are other features that can be examined. The summer project performed with Baham showed no distinction in the OVI line widths from the bright (magnetically open) and dark (magnetically closed) regions in the cores of coronal streamers. Also, a study of the relationship of the streamer structure and heliospheric current sheet orientations at solar maximum did not show a strong correlation as is evident in the streamers observed during the solar minimum period (1996-1997).

While the data analysis continues, there has been some new work in a detailed modeling of the O^{5+} density, temperature and outflow speed along the streamer axis. Results from a collaboration on equatorial streamers with Chen, Esser and Hu, lead to an ApJ publication on stagnation flow O^{5+} ions in the source region of the slow solar wind. This paper (Chen et al. 2004) showed that a 2D MHD model could reproduce the observed perpendicular 1/e velocities and bulk outflow speeds.

2.3 Incorporating the in situ solar wind data.
Miralles collected in situ solar wind data related to the 12 UVCS streamers that were selected from the 1996-1998 solar minimum period. The in situ data was obtained from MTOF/CELIAS/SOHO, SWICS/ACE, SWEPAM/ACE and SWICS/Ulysses instruments. IDL macros were created to extract the necessary information from the MTOF and ACE files. Other codes were written to estimate the 1 AU arrival times for the solar wind coming from the streamers, using information provided by EIT and UVCS. The next step will be to compare the coronal variations of the UVCS streamers with the solar wind variations scaled to 1 AU.

3. Education and Public Outreach (E/PO) Activities.

Michael Baham's summer research was supported by NASA's Minority Initiative in Space Science program. SAO and Southern University at Baton Rouge, a Historically Black College and University (HBCU) forms one of the partnerships for this program. The program has a goal to the increase of the participation of underrepresented students and faculty in NASA space missions.

4. Publications and Abstracts from this Grant:

1. Chen, Y., Esser, R., Strachan, L. and Hu, Y. 2004, Stagnated Outflow of O^{+5} Ions in the Source Region of the Slow Solar Wind at Solar Minimum, Ap J, 602, 415.

2. Strachan, L., Panasyuk, A. V., and Miralles, M. P. 2004a, American Astronomical Society/SPD Meeting Abstracts, 204.

3. Strachan, L., Baham, M., Miralles, M. P., and Panasyuk, A. V. 2004b, Proc. SOHO 15 Coronal Heating 15, (ESA SP-575), 148.